CarbonNanotube-based Actuators using solid and liquid Electrolytes: Investigations of key mechanisms and their differences

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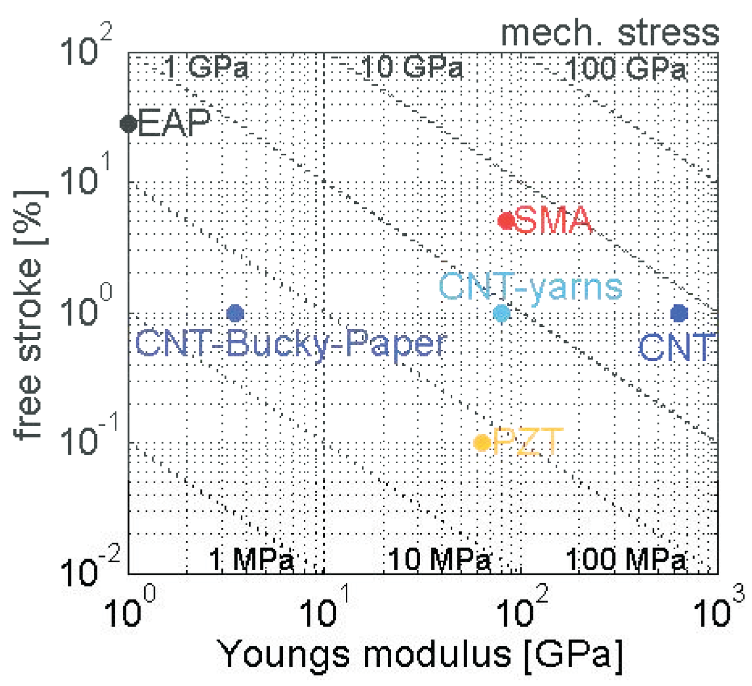
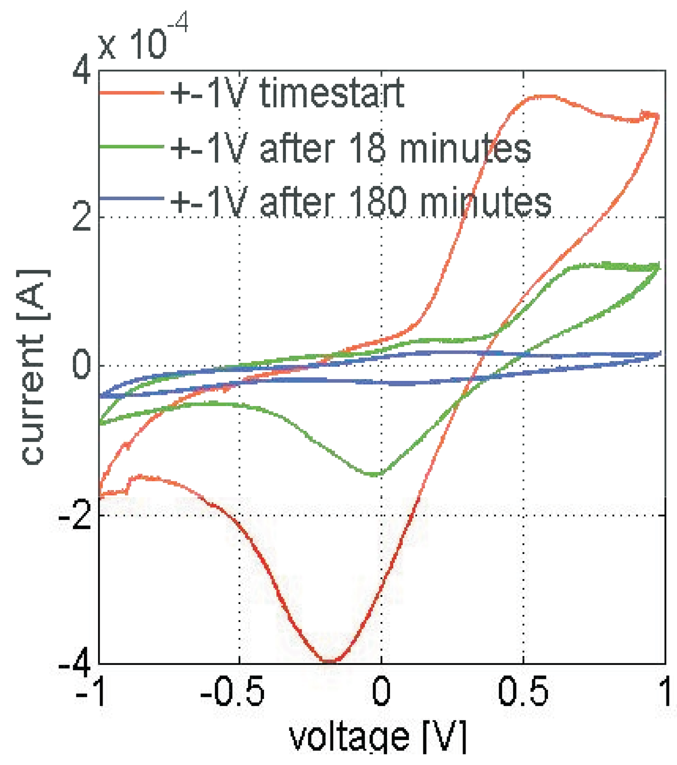
Potentials and preliminary tests

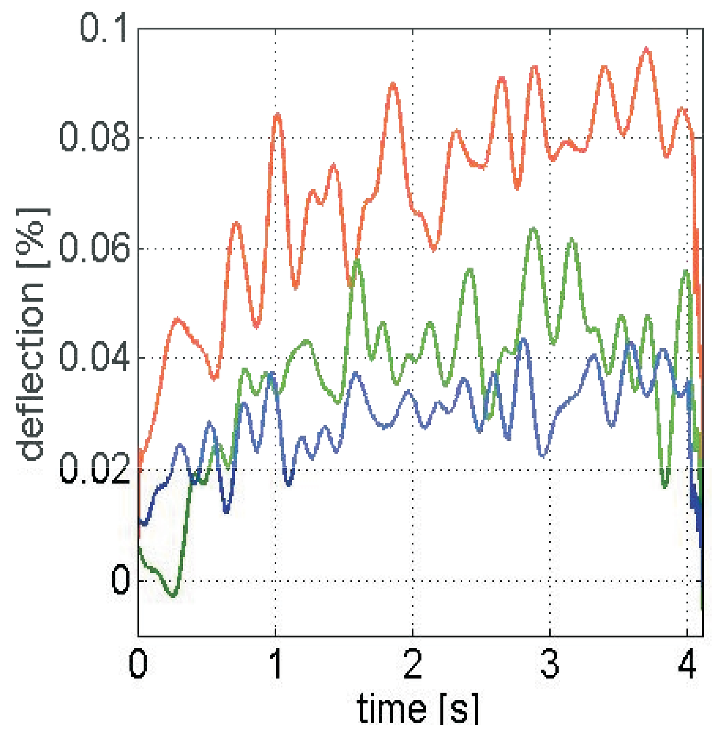


SMA: shape-memory-alloy
EAP: electro-active-polymer
PZT: piezo-electric transducer

figure1 : the potential of CNT-transducers

Carbon nanotubes (CNTs) are because of their excellent properties (low density, high Youngs modulus and stiffness) very interesting for structural applications. They have as well as electro-mechanical transducer the potential (see fig. 1) for adaptive applications (low voltage, high, free stroke). Their active behaviour is caused by an electric field and ion transfer. The first investigations were made with liquid electrolytes like NaCl-solutions in in-plain-test stands (see fig. 8). This transducer-configuration is not practical for structural applications so solid electrolytes like Nafion were tested. The results are unstable and inconsistent (see fig. 2 and 3). More detailed investigations of the solid electrolyte itself and of the influence of the Bucky-Paper-properties are needed. By this approach the driving mechanisms of a CNT-actuator (CNA) can be investigated and the influence of the components on the free stroke can be calculated.





unstable time-dependet behaviour of soild-electrolyt-CNA
figure 2: cyclovoltammetry
figure 3: free stroke at 1V

Qualitymanagement of CNT-powder and produced CNT-mats

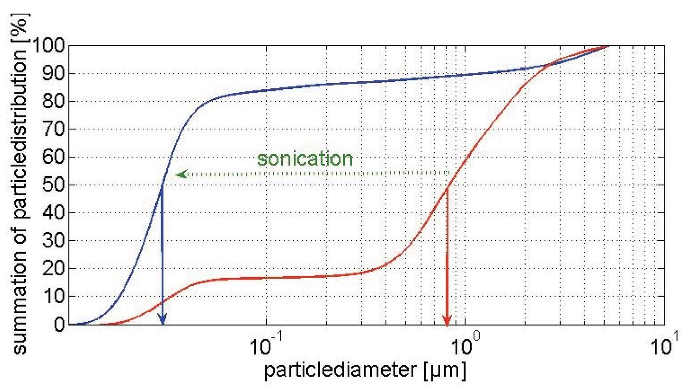


figure 4: CPS-measurement of CNT-dispersion

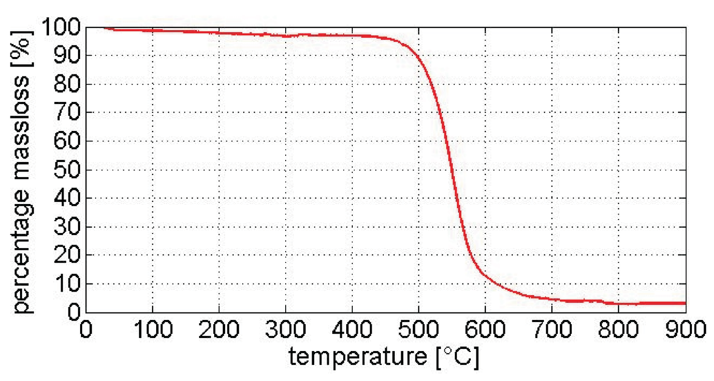


figure 5: TGA-test of CNT-powder

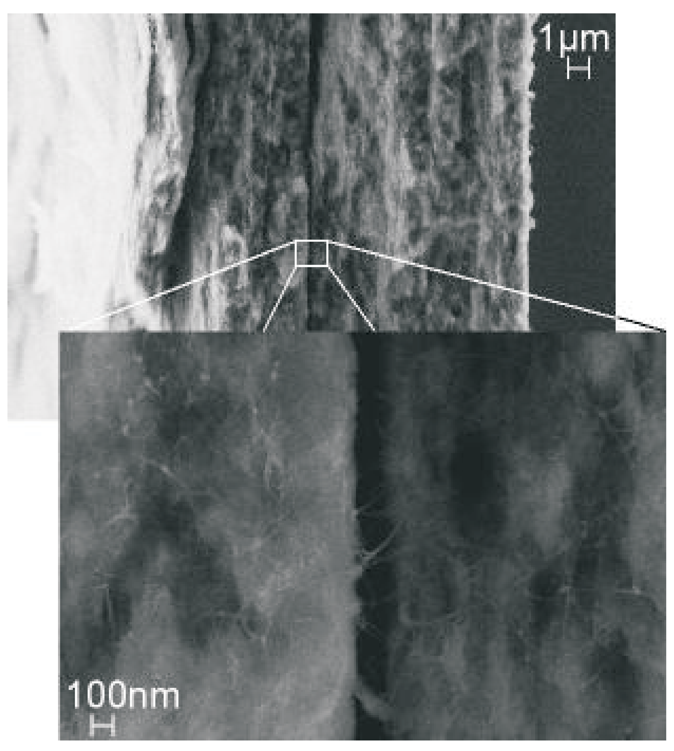


figure 6: crosssection of a cryogene-broken Bucky-Paper .

The purity of the basic-CNT-powder is crucial for the properties of the produced CNT-mat (Bucky-Paper, table 1). Therefore the powder is tested by SEM and TGA-measurements (see fig. 4). The CNT-dispersion is analysed by CPS-method (see fig. 5). The later on produced Bucky-Paper is checked by SEM (see fig. 6), TGA, electrical (see table 1) and optical vice (see fig. 4). The results are compared for getting an idea of the quality of the production process and the internal structure of the individual Bucky-Paper.

supplier	1	2	3	4	5
offered purity [%]	70	97	95	90	>90
conductivity [S/cm]	241	<75	90	<21	58

table 1: different compared CNT-powders

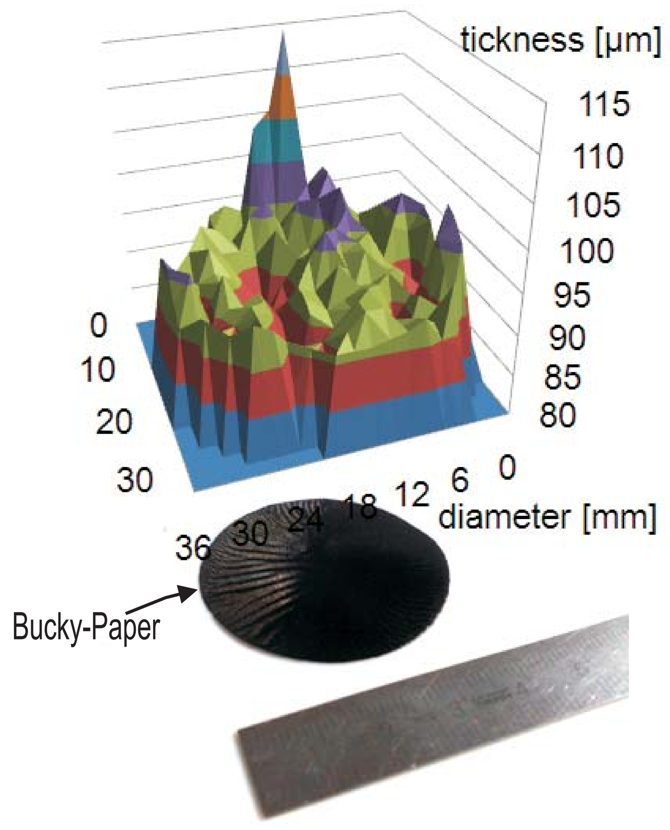


figure 7: optical measurement of a Bucky-Paper-surface

Results of electro-mechanical testing

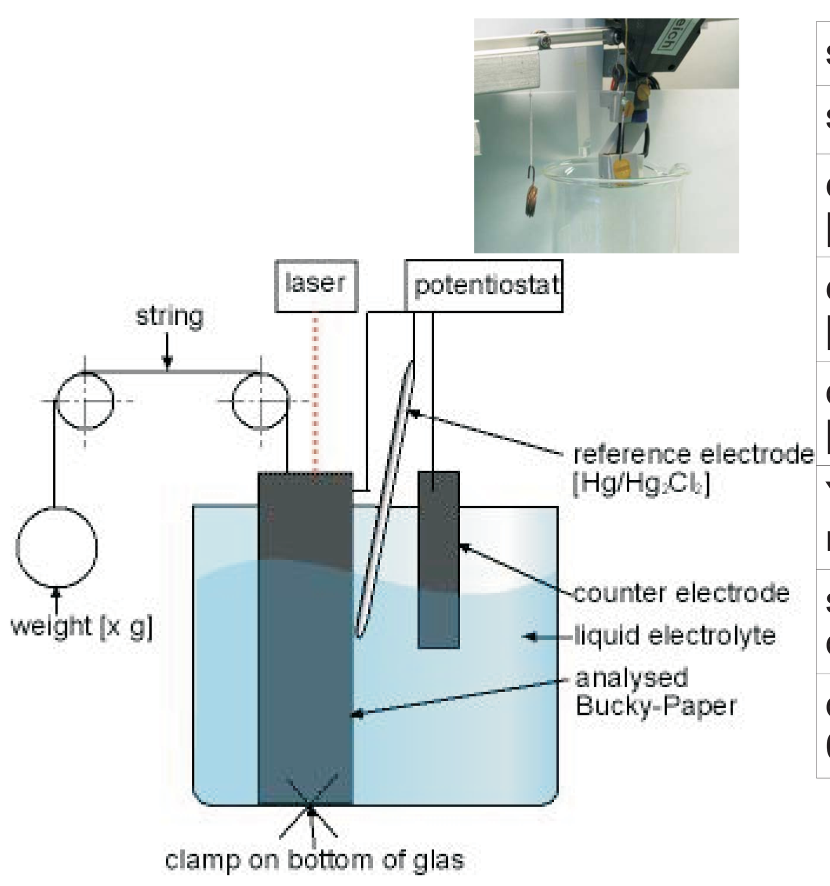


figure 8: experimental setup for CNT-mats in liquid electrolytes

sample	1	2	3	4	5
supplier	1	1	1	1	1
centrifuge time [min]	0	0	0	10	15
conductibility [S/cm]	118	151	86	224	241
density [mg/mm^3]	0,73	0,64	0,66	0,72	0,68
Youngs modulus [MPa]	979	1122	1142	2414	3424
standard deviation [MPa]	178	82	18	207	202
deflection at 0,7V [%]	0,114	0,161	0,154	0,031	0,0203

table 2: result overview

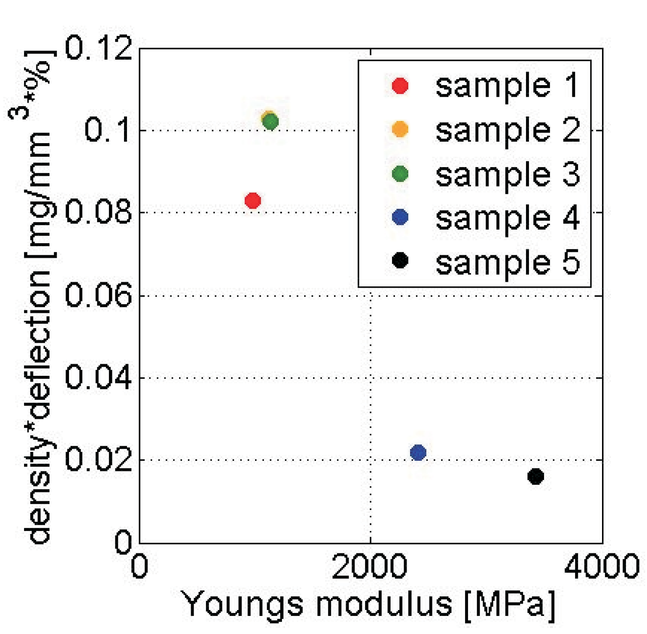


figure 9: exposure of the results

The analysed Bucky-Papers are made out of the powder of supplier 1 and fabricated by a high-pressure filtration of a homogenised and sonicated SWCNT-dispersion. The free stroke of the produced CNT-mats are analysed in an in-plain test stand (fig. 8).The results of the preliminary mechanical,electrical and electro-mechanical tests (see table 2 and fig. 9) show an improvement in conductibility and Youngs modulus with every additional process step (centrifuge time). It seems to be inverse with the free deflection. For being able to make some statements about the driving mechanisms behind, the paper-configuration (amount of MWCNTs/SWCNTs, fullerenes, amorphous carbon, ...) has to be analysed in more detail. Anisotropic CNT-mats (aligned Bucky-Papers) may help to understand the process of CNT-mat elongation.

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